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PANEL SET AP-50-()   
 INTRODUCTION

Panel Set AP-50-() originated in the need for marking front lines or other positions for friendly air-support units. In July 1942, the Watertown Signal Laboratory was authorized by letter (see Inclosure #1) from Chief Signal Officer to start development at once on panel sets, on the basis of tentative military characteristics, and to forward procurement data for an initial supply of panels.

DEVELOPMENT

Extreme urgency for procurement of the equipment precluded the usual preliminary service tests. After laboratory tests on materials to determine color fastness to weather and light, strength of material, reflectivity, and brightness, procurement data were prepared and forwarded in August 1942.

Development was continued to improve the materials used in the panel set. Nomenclature, Panel Set AP-50-A, was assigned to equipment consisting of one red panel and one yellow panel with opposite sides of the panels white, illustrated in Inclosure #2. The red and yellow colors are produced by fluorescent dyes, commercially known as "neon red," and "arc yellow," respectively. Models of the panel sets were procured and forwarded to several boards for comment. Standardization was recommended by SOTC in September 1942.

In July 1943, the Infantry Board reported that the visibility of the fluorescent red and yellow panels was equal to the white in bright sunlight, and better than white with overcast sky. The Infantry Board recommended minor

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modifications consisting principally in having the panels attached to their cases. These changes were embodied in specifications and drawings for Panel Set AP-50-B which were completed in October 1943. Revised military characteristics were recommended by SOTC on 6 September 1943 and approved by ASF, 27 September 1943 (see Inclosure #3).

As a result of the development, Panel Set AP-50-B now consists of one Panel AL-140-B (red/white) and one Panel AL-141-B (yellow/white) with carrying cases attached. The panels are two feet four inches wide by twelve feet long. A photograph of one model of the panel set is inclosed.

#### EMPLOYMENT

Approximately five hundred thousand panel sets have been procured and issued to various branches of the Army Ground Forces.

IMMEDIATE ACTION

OFFICE OF THE CHIEF SIGNAL OFFICER  
WASHINGTON, D.C.

SPSGD 413.44  
(Panel Sets)

SPSGD-G2  
July 15, 1942

SUBJECT: Panel Sets.

TO: Director, Signal Corps General Development  
Laboratory, Fort Monmouth, Red Bank, N. J.

1. Attention is invited to attached copy of letter, file SPSGD 413.44 (Panel Sets), from this office, dated July 7, 1942, Subject: Panels, to your Laboratory.

2. Attention is invited to attached copy of letter from the Army Ground Forces, dated July 3, 1942, Subject: Signalling Panels, with 1st Indorsement approving military characteristics and directing this office to set up development project for signalling panels.

3. This office has been unofficially informed that no service tests would be required by the Army Ground Forces, in order to expedite obtaining panel sets.

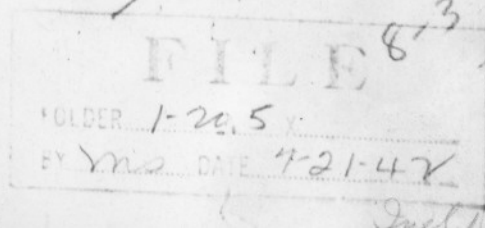
4. Your Laboratory is authorized to initiate a development project immediately and proceed with the development of above referenced panel sets in accordance with attached military characteristics.

5. Your Laboratory is further requested to furnish the following information relative to the proposed development project. Funds for ten (10) service test models should be included in the estimated cost of development, pending official waiver of service tests.

a. Estimated cost of the development by fiscal years with total cost of the development. It is believed that development should be completed in first fiscal year.

b. Statement as to whether funds are available or must be obtained.

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### IMMEDIATE ACTION

OFFICE OF THE CHIEF SIGNAL OFFICER  
WASHINGTON, D.C.

SPSGD 413.44 (Panel Sets)      Le to: SCMDL      Re: Panel Sets  
SPSGD-G2      7/ /42

- c. Estimated date when service test models can be furnished for service test if required.
- d. Estimated time required for service test if necessary.
- e. Estimated date after service test on which procurement data can be expected.
- f. Estimated date on which procurement data can be expected if no service test is required.

6. It is requested that this project be given the highest priority.

By order of the Chief Signal Officer:

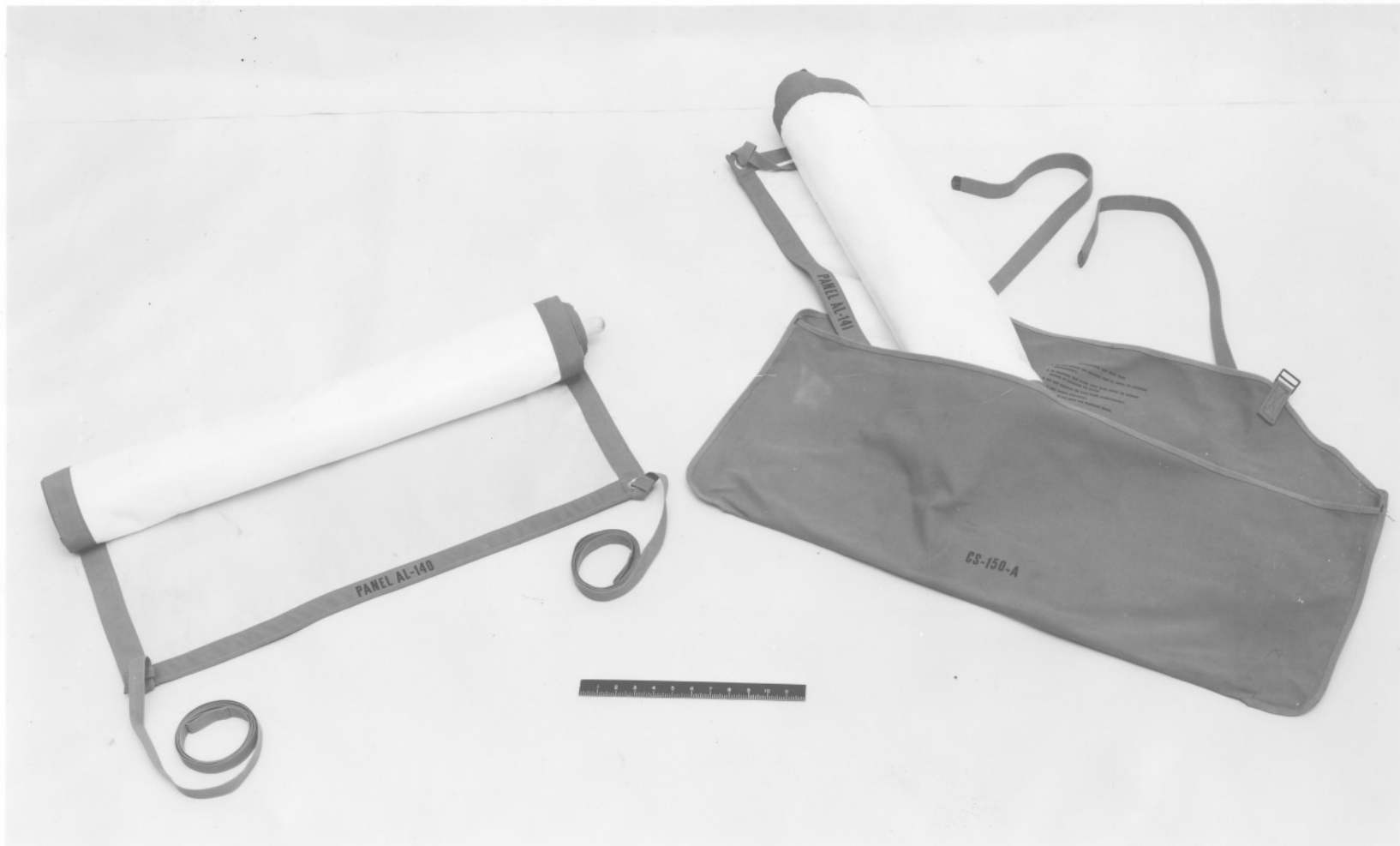
J. D. O'CONNELL,  
Lieutenant Colonel, Signal Corps.

2 Incls.

#1 - Cy le fm AGF,  
7/3/42 to CSO,  
Thru: CG, SOS,

#2 - Cycle fm CSO,  
SPSPGD 413.44  
(Panel Sets),  
7/7/42 to SCGBL.

UNCLASSIFIED



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PANEL AL-140 . PANEL AL-141 . CASE CS-150-A  
Front View

DATE 3-11-43

SIGNAL CORPS GROUND SIGNAL SERVICE

NO. SCGSS 7598

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EXHIBIT "A"  
REVISED MILITARY CHARACTERISTICS FOR PANEL SET AP-50-()

Panels to be similar in design to the present standard Panel AI-121, except white on only one side and coated fluorescent color on the other side; this colored portion to be 12 feet by 2 feet 4 inches.

All panels to be fitted with detachable tying cords.

Each panel and cords to be contained in a carrying case suitable to be carried by troops in the front lines.

Material to be of minimum weight and bulk, consistent with necessary strength for handling and storage.

Panel Set to consist of one (1) each panel colored white on one side and fluorescent yellow on the other, and one (1) each panel colored white on one side and fluorescent red on the other, and additional panels which may be required by the using arms, each panel to be contained in a separate case.

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## SOUND RANGING EQUIPMENT FOR ARTILLERY

### INTRODUCTION

Sound Ranging Set GR-3 is an equipment for detecting the sound of artillery fire or shell detonation and recording differences in arrival time of the sound wave at a maximum of eight microphone positions. Early development of terrestrial sound ranging equipment by the Signal Corps was in accordance with directive from the Adjutant General's Office dated June 1920. At that time, the Coast Artillery was responsible for the tactical and operating requirements and the Signal Corps was made responsible for the development. Under this set up development continued until 1927, at which time the Signal Corps was directed to develop sound ranging equipment for the Field Artillery.

In 1930, engineers from the Signal Corps Laboratories visited the Field Artillery Board, upon invitation, to observe the existing equipment in field operation. As a result of this visit it was agreed that the equipment was not adequate and work was initiated to develop more suitable equipment which would meet the demands of the Field Artillery.

### DEVELOPMENT 1931 - 1938

In 1931, a design was started on a new switchboard and on a new type carbon button microphone. These were completed in 1932 and service-tested by the Field Artillery Board at Fort Bragg, North Carolina. The switchboard was found acceptable but further development was recommended on new types of microphones to replace the carbon button type which had been found to be too noisy.

During 1933 and 1934, a moving coil microphone and a Rochelle salt type were developed. The Field Artillery approved the Rochelle salt microphone as to type and recommended further development.

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In 1939 a study was made of seismic recording equipment used by geophysical exploration companies, with a view of determining:

- a. Suitability for military sound ranging.
- b. Desirable features which might be incorporated in sound ranging equipment.

A twelve channel recording oscillograph and associated equipment was procured from Engineering Laboratories Inc., Tulsa, Oklahoma, as a sample of the most suitable of available seismic recorders. This was tested at Fort Bragg, North Carolina during the summer of 1940 in conjunction with tests of microphones.

Eight types of microphones were tested at Fort Bragg, North Carolina. There were a sufficient number of each type for a complete sound ranging array. The following types were included:

- a. Carbon button
- b. Moving coil (two types)
- c. Condenser
- d. Velocity
- e. Hot wire (two types)
- f. Piezoelectric

Results of testing equipment listed above are given in Engineering Report S-9, "Field Tests on Terrestrial Sound Ranging Equipment and Methods," dated 5 February 1941. The Field Artillery Board recommended:

a. That the condenser microphone, Microphone T-21-( ) be continued as the standard microphone for sound ranging; and the development of a moving coil microphone and hot wire (linear response) type be continued.

b. That commercial geophysical equipment is not suitable for military sound ranging, but certain desirable features should be incorporated in a redesign of Sound Ranging Set GR-3-( ).

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Following the Fort Bragg tests specifications were prepared for Sound Ranging Set GR-3-C. The specifications called for the following improvements and changes in sound ranging equipment:

- a. Replacement of the old magnetic oscillograph units by moving coil oscillograph units, similar to those used in seismic exploration equipment.
- b. Minor improvements in the camera to minimize operational difficulties.
- c. Improvement of the Control Board BD-85-( ).
- d. Simplification and improvement of Switchboard BD-62-( ).
- e. Improvements in the case of Microphone T-21-( ) and the addition of a waterproof bag.

Procurement of this equipment was initiated with an order for 35 sets late in 1940. This first order has been followed by subsequent orders until approximately 200 sets were procured and delivered to Signal Corps depots for issue to troops.

Current developments in progress at the present time are as follows:

- a. Radio Relay Converter which provides means of transmitting the sound ranging signals from microphones to the central station utilizing standard radio equipment Radio Set SCR-510 or SCR-610. This equipment is being procured in limited quantities for issue to troops.
- b. Sound Ranging Set GR-3-T2. This equipment was developed under contract with the Cambridge Instrument Company, Ossining, New York. It provides a nonphotographic means of recording sound arrivals and hence eliminates the requirement for chemical developers and fixers. All essential functions of the central station equipment of Sound Ranging Set GR-3-C are supplied in this new equipment, and with one quarter the weight. This equipment is now being service tested.

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c. Microphone T-23-T5. This is a linear response hot wire microphone in which the frequency response is essentially the same as in Microphone T-21-B but with the added advantages of two-fifths the weight, and better performance in wet weather. This microphone is being service tested at the present time.

#### EMPLOYMENT

Sound Ranging Set GR-3-C is being used by all Field Artillery Observation Battalions in theaters of operation. Such intelligence reports regarding the performance of this equipment as are available state that, except for minor defects, the equipment is satisfactory. One report stated:

"If it can be done, we would like to have sound ranging set smaller, lighter and weatherproof."

As indicated above, the current activity is directed toward this end.

In another report the following statements are made as opinions of high ranking officers:

"Consider the observation battalion one of the most valuable and essential elements of Field Artillery."

"The observation battalion was one of the best pieces of artillery---." The above statements reflect the efficiency and training of personnel, but also indicate adequate equipment.

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DEVELOPMENT 1939 - 1943

In response to suggestions originating with the Commanding Officer, 1st Observation Battalion, Field Artillery, and forwarded through channels, the Signal Corps Laboratories, in the autumn of 1938, prepared an agenda for a proposed conference on sound ranging. The Chief Signal Officer and the Chief of Field Artillery concurred in the Laboratory's proposal of a conference and with the approval of the Adjutant General, a tentative date of 10 December 1938 was decided upon. The conference was held on 12 and 13 December 1938 in the Office of the Chief Signal Officer and was attended by representatives of Industry, Field Artillery, Signal Corps, and G4, General Staff. The conference recommended a program of research and development covering a three-year period, in which specific items of investigation and development were listed. The more important items were:

- a. An investigation to determine whether seismic methods of sound ranging are complementary or supplementary to air sound ranging.
- b. Research to determine whether there is any useful correlation between meteorological conditions and the propagation of sound of artillery firing.
- c. Study of all types of recorders and associated apparatus in use by industry with a view toward securing more effective records and greater convenience in operation-design or procurement to be undertaken if such study seems to warrant that action.
- d. Procure, and modify if necessary, samples of commercial microphones which appear adaptable to sound ranging and submit them to test jointly by the Field Artillery and Signal Corps.
- e. Research to determine the exact forms of arriving sound waves caused by gun fire and shell bursts.

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The program described above has been carried out by the Laboratory except item e. This research is being conducted by NDRC on Army project No. SC-27. Accomplishment by the Laboratory on other items is described in subsequent paragraphs.

From the period of 21 May to 20 June 1939, representatives of this Laboratory, with the assistance of a seismic crew furnished under contract with the Gulf Research and Development Company, Pittsburgh, Pennsylvania, and personnel of the 1st Observation Battalion, Fort Bragg, North Carolina conducted seismic ranging research at Fort Sill, Oklahoma. The results of this research were covered in Engineering Report No. S-2 dated 28 November 1939. This investigation was sufficiently comprehensive to demonstrate the possibilities and limitations of seismic methods as applied to sound ranging and showed definitely that seismic ranging is not a satisfactory method of locating gun fire and shell bursts.

Investigation of effects of meteorological conditions on propagation of sounds of artillery firing was started in 1939 by a theoretical study which resulted in an engineering report titled "Theory of Sound Propagation Through the Atmosphere and an Application to Sound Ranging." This was followed by another report titled "Discussion and Illustration of Methods of Evaluating Meteorological Corrections Along a Sound Path." During the past year and a half a vast amount of data has been accumulated from field work involving recording hundreds of sound arrivals over various ranges and terrains and by means of several types of microphone arrays. At the same time surface and upper air meteorological observations have been made. At the present time this data is being analyzed to determine to what extent the theory referred to above may be applied in practice to sound ranging technique.

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This slow evolution of development on the sound ranging program was carried out under very limited appropriations until January 1935, at which time the Field Artillery Board forwarded a memorandum to the Chief of the Field Artillery lamenting the fact that so little progress had been made in Sound Ranging since the war (World War I) and urged that a full-scale program be initiated to remedy the situation. The memorandum further recommended that appropriations be set up to carry on a more extensive research and development program. As a result of the above mentioned memorandum, the Chief Signal Officer received a 1st Indorsement, dated 3 August 1935, from the Chief of Field Artillery, on basic letter from the Field Artillery Board dated 27 May 1935. In the Indorsement, it was recommended that funds be set up in FY 1937 and the years following for prosecuting research and development of meteorological data; also for the procurement of one complete set of sound ranging equipment per year, of the latest design, starting in 1937, and for five years thereafter.

In the meantime, nomenclature assignment of Sound Ranging Set GR-3-A had been made in July 1935 and development continued on the T1 service test model. This model was completed and forwarded to the Field Artillery Board for service test in December 1935. (Development of this equipment is covered by SCL Engineering Report No. 524). The central station components, viz., oscillograph equipment control board and switchboard are direct prototypes of the corresponding components of Sound Ranging Set GR-3-C.

The report on this service test (Test No. S-7-D) was received by 1st Wrapper Indorsement from the CSO, file 413.634 (GR-3-A) (2-4-36), dated 19 September 1936. It recommended that Sound Ranging Set GR-3-A should be standardized as to type. This recommendation was concurred in by the Chief of Field Artillery with further recommendation that minor changes and

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suggestions contained in the report should be incorporated in the specification of the equipment. The 1st Wrapper Indorsement itself directed that the Laboratory prepare specifications as recommended by the Chief of Field Artillery. The specifications were completed and forwarded to CSigO in February 1937.

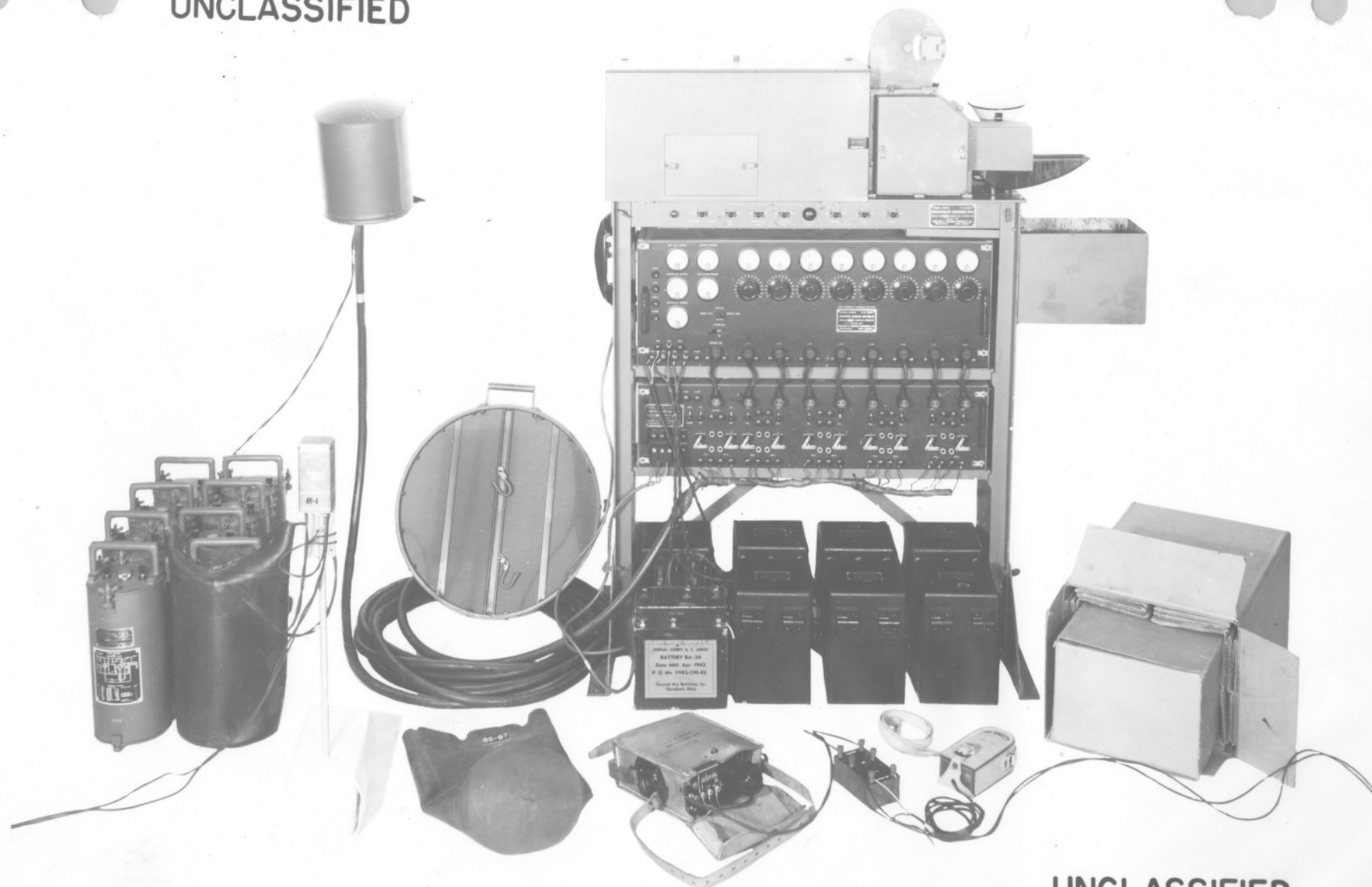
In the process of standardizing the Sound Ranging Equipment, the Adjutant General called upon the Field Artillery for a statement of military characteristics. They were the first military characteristics on the sound ranging set that appear in the files of the Laboratory and were contained in a letter from CSigO to Director, SCL, dated 18 June 1937, subject: "Military Characteristics of Sound Ranging Set GR-3-A."

While the specifications and procurement data were being assembled on Sound Ranging Set GR-3-A, the equipment was improved. Most notable among the changes made was a new Microphone T-21-A-T1. This was a condenser microphone which was designed as a possible substitute for Microphone T-21 (Rochelle salt), inasmuch as the latter which had been standardized was not completely satisfactory. The new microphone was completed and submitted to the Field Artillery for Service Tests in December 1937. A favorable service test report on the microphone was completed on 12 January 1938 and work was begun on Specification 172-8 covering the microphone.

One unit of Sound Ranging Set GR-3-A was procured and issued to the 1st Observation Battalion FA during the early part of 1938; and one unit of Sound Ranging Set GR-3-B in January 1939. (It should be noted that at this time there was only one FA observation battalion and two sets of sound ranging equipment in the U. S. Army).

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SOUND RANGING SET GR-3-C

Showing Recording Equipment Assembly and Associated Field Equipment

DATE 9-22-43

SIGNAL CORPS GROUND SIGNAL SERVICE

NO SCGSS 9382

COPY OF COPY:jb

In reply refer to  
400.112 Gen.

Office of the Chief Signal Officer  
Washington

January 21, 1930

Subject: Status of Certain Active Projects - "General  
Signal Section."

To: Officer in Charge, Signal Corps Laboratories,  
Fort Monmouth, N.J.

1. The following information on questions relating to certain active projects, "General Signal Section", which were discussed during my recent visit to the Laboratories is forwarded as requested:

Project No. 57 (Sound Ranging for Artillery) - Authority for the development of sound ranging equipment for the Field Artillery is contained in the 10th Ind. from the Adjutant General to the Chief Signal Officer dated April 19, 1927 (to basic letter from Chief of Field Artillery to Adjutant General's Office dated January 3, 1927; subject - Sound Ranging for Field Forces) which reads as follows:

"AG 321.96 (1-3-27) (Misc.)D 10th Ind.

AMS/CCD

War Department, A.G.O., April 19, 1927. - To the Chief Signal Officer.

1. The Chief Signal Officer is authorized and will proceed, subject to the availability of funds, with a project for the development of sound ranging equipment for Field Artillery, utilizing wire communications between the microphones and the central station.

2. The use of radio communication between the microphones and the central station should also be developed with a view to determining which method is preferable and of providing alternative methods of communication, if found desirable.

By order of the Secretary of War:

(Signed) Robert L. Collins  
Adjutant General."

By order of the Acting Chief Signal Officer:

WM. R. BLAIR  
Major, Signal Corps.

COPY OF COPY

OCSigO.413.684-  
(GR-3-A)

June 18, 1937

Military Characteristics of Sound Ranging Set GR-3-A

Director, Signal Corps Laboratories,  
Fort Monmouth, N.J.

1. During the process of standardization of Sound Ranging Set GR-3-A, the Adjutant General called upon the Chief of Field Artillery for a statement of military characteristics covering the new set. In response to this directive the Chief of Field Artillery submitted the following military characteristics, which were approved as submitted:

A system, and equipment pertaining thereto, for determining the point of origin of a particular sound source, which may be amongst many similar sound sources, by means of sound waves originated by the discharge of a cannon or the explosion of a projectile at distances below 30,000 yards; the equipment to be suitable for use with mobile field forces; the accuracy of location of the sound source to be of the order of one-half of one percent of the distance to the sound source.

2. It will be noted that these approved characteristics differ from those under which the set was developed, particularly with respect to range and accuracy of location. They were based on what the Field Artillery Board considered the present set to be capable of and were purposely made broad in other respects in order not to hamper standardization. The records on file in this office, however, leave some doubt as to whether the present set is capable of meeting the new range and accuracy requirements.

3. The comments of your laboratory are desired.

By order of the Acting Chief Signal Officer:

H. P. Browning,  
Major, Signal Corps.

1st. Ind. on next sheet

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FM(SCL) Proj. 1  
(I.&R. GR-3-A)  
OCSigO. 413.684 (GR-3-A)  
(6-18-37)

1st Ind.

LLC:D

SIGNAL CORPS LABORATORIES, FORT MONMOUTH, OCEANPORT, N.J. July 15, 1937.  
To: Chief Signal Officer, War Department, Washington, D.C.

1. With reference to the range and accuracy requirements of Sound Ranging Set GR-3-A, the service tests of this equipment indicated an ability to range with the degree of accuracy specified on 75-mm guns and projectiles at 20,000 yards under favorable conditions. On larger calibers, i.e., 4.7" and 155-mm guns, ranges considerably in excess of this were obtained. However, as the military characteristics quoted in basic communication are very broad and do not specify the caliber of cannon by which performance is to be measured, it is considered highly probable that ranges of 30,000 yards could under proper conditions be obtained with the accuracy specified provided the sound source is a cannon or projectile of sufficient caliber.

WM. R. BLAIR  
Lt. Col., Signal Corps  
Director